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[Continued on next page]

(54) Title: A COPY-PROTECTED COMPACT DISC AND METHOD FOR PRODUCING SAME

CTRL	PT	PTIME		
		PMIN	PSEC	PFRAME
AUDIO	1	0	2	0
AUDIO	1	0	2	0
AUDIO	1	0	2	0
AUDIO	2	3	2	0
AUDIO	2	3	2	0 (a)
AUDIO	2	3	2	0
AUDIO	3	6	2	0
AUDIO	3	6	2	0
AUDIO	3	6	2	0
AUDIO	1	0	2	0
AUDIO	1	0	2	0
AUDIO	1	0	2	0
DATA	2	3	2	0
DATA	2	3	2	0 (b)
DATA	2	3	2	0
AUDIO	3	6	2	0
AUDIO	3	6	2	0
AUDIO	3	6	2	0

TOC *i*

Misleading item

TOC *i+1*

(57) Abstract: A copy-protected compact disc and a method for producing the optical disc and preventing unauthorized copying is provided. In one embodiment, the contents of at least one of the lead-in items in the optical disc are altered so that it is no longer uniform, thereby making a copied disc effectively corrupted and unplayable.

WO 03/049107 A2

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

A COPY-PROTECTED COMPACT DISC AND METHOD FOR PRODUCING SAME

FIELD OF THE INVENTION

The present invention relates to copy protection, and, more particularly, to a method and system for the copy protection of audio compact discs (CDs).

BACKGROUND OF THE INVENTION

Both computer software and digital audio recordings are commonly recorded on to compact discs (CDs). Computers, such as personal computers (PCs) read audio CDs differently than do consumer CD playback systems, such as car players, boom boxes, portable devices and hi-fi players, for example).

CDs are almost universally made in accordance with the following international standards:

- International Standards Organization (ISO) 9660: Information Processing—Volume and File Structure of CD-ROM for Information Interchange, ISO Standard 13490-1
- International Electrotechnique Commission (CEI-IEC) 908 (generally conforming to what is known as the "Red Book")
- ISO/IEC 10140 (generally conforming to what is known as the "Yellow Book")

Because the data recorded on compact disc is in a digital format with an error-correction capability, it is possible to make faithful copies whose playback is indistinguishable from that of the original disc from which the copy was made. Furthermore, equipment for producing compact discs is readily-available and relatively inexpensive, both for stamped discs and for recorded discs. As a result, the unauthorized or illegal copying of compact discs has thus become a serious problem.

Consumers who have purchased inexpensive computer systems and CD recorders are capable of making copies of original CDs, thereby depriving the copyright owner of a sale.

Only suitable copy-protection methods can succeed in reducing the increasing flood of these unauthorized recorded disc copies. Unfortunately existing

prior art copy-protection methods are unsuitable and/or inadequately effective for the audio compact disc.

SUMMARY OF THE INVENTION

The present application relates to a copy-protected compact disc and a method for producing the optical disc and preventing unauthorized copying. The system and method of copy protection also protects CD-R discs and prevents their being extracted on to a personal computer (PC).

There is thus provided, in accordance with an embodiment of the present invention, an optical disc having at least one session, which includes a lead-in having a plurality of subcoding blocks. Each of the plurality of subcoding blocks includes an item in channel Q, which may include at least a Point (PT), Adr/Ctrl, Pmin, Psec and Pframe. The Point of at least one of the plurality of subcoding blocks is identical to the Point in at least one other of the plurality of subcoding block and the value of at least one of a group including Adr/Ctrl, Pmin, Psec and Pframe in at least one of the plurality of subcoding blocks may differ from the value of at least one of the corresponding group of Adr/Ctrl, Pmin, Psec and Pframe in at least one other of the plurality of subcoding blocks.

In addition, in accordance with an embodiment of the present invention, the plurality of subcoding blocks may include a repetition of items, wherein at least one of the group including Adr/Ctrl, Pmin, Psec and Pframe of at least one of the repetition of items may be altered.

Furthermore, in accordance with an embodiment of the present invention, at least one of the values in the control data of the one of the repetition of items may be replaced by a misleading or invalid value. The misleading or invalid value may include an indication that an audio portion of the disc contains data or vice versa. Alternatively, the misleading or invalid value may indicate that the starting time of the track is invalid or misleading.

Furthermore, in accordance with an embodiment of the present invention, at least one of the values Cyclic Redundancy Check (CRC) of the one of the repetition of Items is replaced by a misleading or invalid value.

In addition, in accordance with an embodiment of the present invention, the plurality of subcoding blocks may include a continuous repetition of table of contents (TOCs). At least one item in at least one of the group including Adr/Ctrl,

Pmin, Psec and Pframe of one of the repetition of table of contents (TOCs) may have a different value from the corresponding item in at least one other of the repetition of table of contents (TOCs). One of the repetitions of table of contents (TOCs) may include a misleading or invalid triplet. The misleading or invalid triplet may include an indication that an audio portion of the disc contains data or vice versa. Alternatively, the misleading or invalid value may indicate that the starting time of the track is invalid or misleading.

Furthermore, in accordance with an embodiment of the present invention, the misleading or invalid triplet may include a misleading or invalid point Alternatively, the misleading or invalid triplet may include setting the Adr field to an invalid value.

Furthermore, in accordance with an embodiment of the present invention, one of the repetitions of table of contents (TOCs) may include an interleaved pattern of alternating valid and invalid triplets. The alternating valid and invalid triplets may be represented by audio and data item respectively, or vice versa. Alternatively, the pattern may be randomized. Each track may be represented by at least one audio and one data item.

Furthermore, in accordance with an embodiment of the present invention, one of the points of the repetition of table of contents (TOCs) may remain uniform.

Furthermore, in accordance with an embodiment of the present invention, the one of the repetition of table of contents (TOCs) may include one of a group including at least one misleading or invalid triplet.

Furthermore, in accordance with an embodiment of the present invention, the plurality of subcoding blocks may include a combination of a repetition of items, and continuous repetition of table of contents (TOCs). One of the group including Adr/Ctrl, Pmin, Psec and Pframe of at least one of the repetition of items may be altered and at least one item in at least one of the group including Adr/Ctrl, Pmin, Psec and Pframe of one of the repetition of table of contents (TOCs) may have a different value from the corresponding item in at least one other of the repetition of table of contents (TOCs).

In addition, in accordance with an embodiment of the present invention, the plurality of subcoding blocks may include a plurality of zones, wherein an alteration algorithm may be applied to each of the plurality of zones. The plurality of zones may include any combination of a group including a valid table of

contents (TOCs), an invalid table of contents (TOCs), an interleaved pattern of alternating valid and invalid entries and one of a group including at least one data track or at least one invalid triplet. The invalid table of contents (TOCs) may include one repetition of the table of contents (TOCs), which is different from at least one other of repetition of the table of contents (TOCs).

Furthermore, in accordance with an embodiment of the present invention, the A0, A1, and A2 points may have invalid or misleading values.

In addition, in accordance with an embodiment of the present invention, the optical disc may include a multi-session disc having a plurality of multi-session pointers, wherein at least one of the plurality of multi-session pointers may be invalid or misleading. Alternatively, the optical disc may include a multi-session disc having a plurality of multi-session pointers, wherein at least one of the plurality of multi-session pointers may be invalid or misleading.

Furthermore, in accordance with an embodiment of the present invention, the optical disc may include one of a group including a compact disc (CD) a recordable compact disc (CD-R) and a CD-Rewritable compact disc (CD-RW).

Additionally, in accordance with an embodiment of the present invention, there is also provided, a method for protecting an optical disc from unauthorized copying. The method includes the steps of:

generating a lead-in, the lead-in having a plurality of subcoding blocks, each of the plurality of subcoding blocks, includes an item having at least a Point (PT), Adr/Ctrl, Pmin, Psec and Pframe, and

altering the value of at least one of a group including Adr/Ctrl, Pmin, Psec and Pframe in at least one of the plurality of subcoding blocks to a value different from at least one of the corresponding group of Adr/Ctrl, Pmin, Psec and Pframe in at least one other of the plurality of subcoding blocks.

Additionally, in accordance with an embodiment of the present invention, there is provided, a method for generating a valid lead-in containing continuous repetition of table of contents (TOCs). The method includes the steps of:

reading the Program Area subcoding blocks pointed to by the continuous repetition of table of contents (TOCs); and

discarding invalid or misleading triplets, so determined by the reading of Program Area.

Finally, there is also provided in accordance with an embodiment of the invention, a further method for generating a valid lead-in containing continuous repetition of table of contents (TOCs),. The method includes the steps of:

reading the entire Program Area;

selecting the channel Q of a frame to be analyzed;

comparing the track number (TNO) of the analyzed frame with the track number (TNO) of the previous frame;

if the track number (TNO) of the analyzed frame is greater than the track number (TNO) of the previous frame, creating a TOC entry with the new track number and the ATime of the analyzed frame.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

Figs. 1a-1e are a schematic prior art representation of the structure of a compact disc (CD);

Fig. 2 is a schematic prior art representation of portions of two consecutive uniform TOCs in a given session of the CD of Fig. 1;

Fig. 3 is a prior art schematic representation of standard track pointers of the CD of Fig. 1;

Fig. 4 is a schematic prior art representation of multi-session pointers of the CD of Fig. 1;

Fig. 5 is a schematic prior art representation of a uniform TOC containing uniform triplets of the CD of Fig. 1;

Fig. 6 is a schematic illustration of a system for the copy protection of audio compact discs (CDs), according to an embodiment of the present invention;

Fig. 7 is a schematic illustration of a system for the copy protection of audio compact discs (CDs), according to a further embodiment of the present invention;

Fig. 8 is a schematic illustration of a system for the copy protection of audio compact discs (CDs), according to a further embodiment of the present invention;

Fig. 9 is a schematic illustration of a system for the copy protection of audio compact discs (CDs), according to a further embodiment of the present invention;

Fig. 10 is a schematic illustration of a system for the copy protection of audio compact discs (CDs),according to a further embodiment of the present invention;

Fig. 11 is a schematic illustration of a system for the copy protection of audio compact discs (CDs), according to a further embodiment of the present invention;

Fig. 12 is a schematic illustration of a system for the copy protection of audio compact discs (CDs), according to a further embodiment of the present invention;

Fig. 13 is a schematic illustration of a system for the copy protection of audio compact discs (CDs).according to an embodiment of the present invention;

Fig. 14 is a schematic illustration of a system for the copy protection of audio compact discs (CDs).according to a further embodiment of the present invention;

Fig. 15 is a schematic illustration of a system for the copy protection of audio compact discs (CDs).according to a further embodiment of the present invention;

Fig. 16 is a schematic illustration of a system for the copy protection of audio compact discs (CDs).according to a further embodiment of the present invention;

Fig. 17 is a schematic illustration of a system for the copy protection of audio compact discs (CDs).according to an embodiment of the present invention;

Fig. 18 is a schematic illustration of a system for the copy protection of audio compact discs (CDs).according to a further embodiment of the present invention;

Fig. 19 is a schematic illustration of a system for the copy protection of audio compact discs (CDs).according to a further embodiment of the present invention;

Fig. 20 is a schematic illustration of a system for the copy protection of audio compact discs (CDs).according to a further embodiment of the present invention;

Fig. 21 is a flow-chart illustration of a method of generating a Polymorphic TOC disc, according to an embodiment of the present invention;

Fig. 22 is a flow-chart illustration of a technique for creating a true lead-in, according to an embodiment of the present invention; and

Fig. 23 is a flow-chart illustration of a further technique for creating a true lead-in, according to a further embodiment of the present invention.

GLOSSARY

The following glossary of terms and acronyms are used in the present patent application.

Term	Description
CD	Compact Disc including premastered, CD-R, and CD-RW discs.
Channel Q	Bits d_2 of a subcoding block, arrayed as a single 12-byte structure, delimited by S0 and S1 subcoding sync patterns.
CRC	Cyclic Redundancy Check. Field in channel Q that checks validity of channel Q data.
Identical Items	Items that have the same values in the fields: CTRL, ADR, POINT, PMIN, PSEC, and PFRAME.
Identical Triplets	Two triplets that have the same values in the fields: CTRL, ADR, POINT, PMIN, PSEC, and PFRAME.
Identical TOCs	Two TOCs in which each triplet in the first TOC is identical to a corresponding triplet in the second TOC.
Invalid Item	An item that cannot be interpreted correctly under the rules of IEC 908. For example, an item that has an ADR value that is not 1, 2, or 5, or an item that has an invalid CRC.
Item	Channel Q of a subcoding block in the lead-in.
Lead-in	Track 0 of a session, contains TOCs in channel Q.
Lead-out	Control portion of a session that follows a session's tracks.
Misleading Item	An item that can be interpreted correctly, but does not match the track number, index, or control values in channel Q in the Program Area frame pointed to in its ATIME fields.
Polymorphic	Not uniform. A polymorphic triplet contains at least one invalid or misleading item. A polymorphic lead-in is defined as a lead-in having a at least two non-identical TOCs or at least one triplet in one TOC that is not uniform
PTIME	Point Time. Absolute starting time of POINT. In an item, PTIME is encoded in the fields PMIN to PFRAME as defined in Table 1.
Session	Section of a CD containing either audio or data tracks, or a combination of the two. A standard session contains a lead-in, at least one track, and a lead-out.
TOC (Table of Contents)	The minimum number of items required to form a complete description of a session, including track pointers, A0, A1, and A2 entries as well as any multi-session pointers that

Term	Description
	are encapsulated within the items. TOCs are repeated to end of a session's lead-in.
Track	Single content unit (program item) on a CD.
Triplet	Three consecutive lead-in items following a POINT boundary.
Uniform Lead-in	Lead-in composed only of identical TOCs.
Uniform TOC	TOC composed only of identical triplets.
Uniform Triplet	Triplet composed of three identical items.

DESCRIPTION OF EMBODIMENTS

The present application relates to a copy-protected compact disc and a method for producing the disc and preventing unauthorized copying. The present invention provides an improved method that changes the contents of any lead-in item in any optical disc so that it is no longer uniform, as described in embodiments of the present invention, hereinbelow, so that the copied disc becomes effectively corrupted and unplayable.

Reference is now made to Figs. 1a-1e which schematically represent the structure of a compact disc (CD) having uniform lead-ins. The exemplary disc is shown, for purposes of clarity and simplicity only, as having two sessions: Session 1 with three audio tracks (tracks 1–3), followed by Session 2 containing a single data track (track 4).

Fig. 1b illustrates the structure of the lead-in for session 1, showing that the lead-in is composed of uniform Table of Contents (TOCs) consisting of A0,A1, A2 and track pointers, that are repeated throughout the length of the lead-in. The TOC for session 2 (not shown) is similar to session 1 but contains only a single data track.

Fig. 1c shows the triplets in each TOC, with the multi-session pointers (B0 and C0). Fig. 1d shows that each triplet is composed of three items. In a uniform lead-in, each item in a triplet is identical. Fig. 1e shows the fields in a lead-in item.

The inventors have realized that it is possible to protect CDs from unauthorized copying by making changes to the session lead-in. One novelty of the copy protection method is that disc produced by the copy protection method applies these techniques to CD-R discs, thereby protecting them and preventing them from being extracted on a PC. Due to the raw write modes available in current home CD-R writing hardware and software, no special modifications are needed to implement the lead-in copy protection on CD-R and CD-RW discs.

Each session in a CD has a lead-in, which contains repetitions of the Table of Contents (TOC).

If a session's lead-in contains invalid data, a PC may not be able to read it properly. However, consumer CD playback systems (such as car players, boom boxes, portable devices, and hi-fi players) can ignore certain types of invalid lead-in data. For example, certain alterations to the lead-in of a disc's audio session

make it difficult for a PC CD-ROM drive to correctly interpret the session, and hence, the disc, but these alterations do not affect the ability of consumer playback systems to play the disc.

In addition, certain CD reading devices read different offsets of the lead-in to determine the TOC, allowing specific instances of the TOC to target specific players.

In the present application the term "polymorphic" is defined as non-uniform. A polymorphic triplet is defined as a triplet, which contains at least one invalid or misleading item. A polymorphic lead-in is defined as a lead-in having a at least two non-identical TOCs or at least one triplet in one TOC that is not uniform.

Channel Q

According to IEC 908, a subcoding block consists of the subcoding symbols in 98 consecutive EFM frames, delimited by the S0 and S1 sync patterns. Channel Q is the second most significant bit in each subcoding symbol following the sync pattern. In the program area of a disc, channel Q generally contains timing information, such as absolute disc time or track time. In the lead-in, however, channel Q contains information about the layout of the disc.

Table 1 describes a single item (ITEM) in channel Q, using the fields defined for the lead-in. For convenience, field names are used to refer to the bit position, even though the names are only valid for ADR = 1 or ADR = 5.

Table 1: Single ITEM in lead-in channel Q (Mode 1)

Field	Length
CTRL (Control)	4 bits
ADR (Mode)	4 bits
TNO (Track Number)	8 bits
POINT	8 bits
MIN	8 bits
SEC	8 bits
FRAME	8 bits
ZERO	8 bits
PMIN	8 bits
PSEC	8 bits
PFRAME	8 bits
CRC	16 bits

Uniform TOCs

Fig. 2 is a schematic representation of portions of two consecutive uniform TOCs in a given session, showing selected fields. In this figure, and those based on it, "AUDIO" and "DATA" are used instead of their corresponding values of 00XXb and 01XXb. For clarity this partial table omits the A0–A2 pointers and multi-session pointers.

A0—A2 Items

In addition to the track pointers, lead-ins contain A0-A2 items, which state the number of the first track in a disc (A0), the number of the last track (A1) and the starting time of the current session's lead-out (A2). These items follow the standard track pointers as shown in Fig. 3.

Multi-session Discs

In addition to the track pointers and A0-A2 pointers, a multi-session disc has a further set of pointers that allow navigation between sessions in a linked list. These pointers are called the multi-session pointers. They are interleaved between the standard track pointers, referenced 60, as shown in Fig. 4 with the multi-session pointers bolded, referenced 62 and 64.

Lead-ins

A uniform lead-in is composed of Table of Contents (TOCs), with a TOC being the minimum number of items needed to fully describe a session. A uniform TOC contains uniform triplets. A triplet is composed of three identical contiguous items that follow a POINT boundary. Two items are said to be identical if the values of the corresponding fields indicated by an * are identical (see Fig. 5). A triplet is said to be uniform if all three of its items are identical.

In the present invention, a lead-in is altered so that it contains valid, misleading, and/or invalid items arranged in a polymorphic manner, meaning that at least two of the lead-in's TOCs are not identical or at least one triplet in one of the lead-in's TOCs is not uniform.

As described below, these properties make it possible to alter the lead-in so as to render the disc useless to PCs without rendering the disc unreadable to a home or auto system.

One method of changing a lead-in is to alter items so that not all items in a triplet are uniform.

Reference is now made to Fig. 6, which illustrates a system for the copy protection of audio compact discs (CDs).according to an embodiment of the present invention. Fig. 6 illustrates the alteration of a portion of the lead-in so that the triplet is not uniform.

In the example of Fig. 6, the second of three identical AUDIO items (marked as A1b in Fig. 2) has been altered so as to indicate DATA instead of AUDIO (the triplet item is bolded and the alteration is marked by the letter "a"). In a further embodiment of the present invention, illustrated in Fig. 7, the third of three identical AUDIO items (marked as A1c in Fig. 2) has been altered to show an invalid CRC item of 5 (instead of 45).

In a further embodiment of the present invention, polymorphic TOCs are created while preserving uniform triplets. It will be appreciated by persons knowledgeable in the art that there are many possible methods of creating non-uniform (polymorphic) TOCs. Non-limiting examples of copy protection using polymorphic TOCs include comparing a track number with an iteration number and amending the item accordingly, or comparing the PTIME fields with known boundary values and amending the item according to physical location within the lead-in.

Reference is now made to Fig. 8 which illustrates an embodiment of the invention in which a portion of the lead-in (AUDIO triplet (marked A1 in Fig. 2 and "a" in Fig.8) is altered to a DATA triplet (marked "b" in Fig.8).

Fig. 9, to which reference is now made, illustrates a further embodiment of the invention in which the point (PT) of a triplet is amended to 3 (marked by the letter "a") instead of the correct value of 2 (A5 in Fig. 2).

Reference is now made to Fig. 10, which illustrates a further embodiment of the invention in which polymorphic TOCs are created by setting the Mode (ADR) field of an item or an entire triplet to a value other than 1, 2, or 5. In the exemplary embodiment of Fig. 10, the ADR of a triplet (marked "a") is set to 8 instead of the correct value of 1.

In a yet further example of an embodiment of the invention, polymorphic TOCs are produced by creating a "checkerboard" pattern of misleading and valid items. Reference is now made to Figs. 11-13. Fig. 11 is an exemplary illustration of a "regular" checkerboard composed of alternating valid AUDIO and misleading DATA items.

In the example of Fig. 11, a disc with 15 audio tracks is protected by marking alternate tracks as DATA (setting the data bit in the ADR/Ctrl byte), instead of AUDIO, thereby creating misleading items. It will be appreciated by persons knowledgeable in the art that any other technique of creating misleading items may be used in place of setting the data bit.

Fig. 12 is an exemplary illustration of a randomized checkerboard of polymorphic TOCs. In the example of Fig. 12, a "regular" checkerboard is first created (similar to Fig. 11) and then the checkerboard is randomized. Each track is represented by at least one A (AUDIO) and one D (DATA) item.

Reference is now made to Fig. 13, which illustrates a further embodiment of the invention using polymorphic TOCs, in which a partial checkerboard is created. In this case, a "regular" and/or a randomized checkerboard is created with the additional modification of containing at least one unprotected row (a row of AUDIO items shown bolded in Fig. 13).

Reference is now made to Fig. 14, which illustrates a further embodiment of the invention utilizing polymorphic TOCs. In the example of Fig. 14, a valid TOC is created at an offset of the lead-in (column 110). A number of misleading

TOCs are added (columns 112, 114, 116) containing only one data track. Finally, the sequence is terminated with a single invalid triplet (column 118).

It will be appreciated by persons knowledgeable in the art that alterations may be also be made to an individual triplet (as described hereinabove with reference to Fig's 6 and 7 for example) as well as alterations to a TOC, either independently or any combination with polymorphic triplets and TOCs.

Reference is now made to Fig. 15, which illustrates a further embodiment of the invention in which a lead-in is altered so as to comprise a combination of polymorphic triplets and polymorphic TOCs. The example of Fig. 15 illustrates a polymorphic triplet (marked by the letter "a") in which the AUDIO item has been amended to a DATA item and the polymorphic TOC (marked by the letter "b"), in which the AUDIO triplet has been amended to a DATA triplet.

Reference is now made to Fig. 16, which illustrates a further embodiment of the invention in which both polymorphic triplets and polymorphic TOCs are applied to the same lead-in (known as a "composite" disc). Such a lead-in contains zones, with a zone being a series of consecutive TOCs sharing a common alteration algorithm.

In the example of Fig.16, the first zone 120 comprises triplets, which are all polymorphic. The second zone 122 comprises valid uniform TOCs, while the third zone comprises a checkerboard 123 (similar to the checkerboard embodiments described hereinabove with reference to Fig. 12 and 13). In the fourth zone, all of the items are DATA as described hereinabove with reference to Fig. 14. As will be appreciated by persons knowledgeable in the art, the examples are non-limiting and may be applied to any session of a "composite" disc.

Reference is now made to Fig. 17 which illustrates a further embodiment of the invention in which the A0–A2 items in polymorphic TOCs may be changed. The Control field (C/A) may be amended so that triplet 126 is non-uniform, that is part of the C/A of triplet 126 is amended to 41h (instead of 01h –see triplet 50 of Fig. 3).

In one embodiment, the A0–A2 items of a triplet 128 (marked "a") may be left unaltered, regardless of processing of triplet 126.

The example of Fig. 17 further illustrates two alternative ways of altering the A0–A2 items. In triplet 130 (marked "b"), the A0–A2 items may be invalidated (to "41") in the same ways as the surrounding track pointers of triplet 126. In triplet

132, the A0–A2 items may be invalidated in a way that is different from the surrounding track pointers so that part of the C/A is altered to give a misleading (and invalid) reading of "48".

As illustrated, modifications may occur in any of the three items of a triplet.

While this example demonstrates polymorphic triplets with A0–A2 items, it will be appreciated by persons knowledgeable in the art that A0–A2 items may also be applied to polymorphic TOCs.

Reference is now made to Fig. 18, which illustrates a further embodiment of the invention in which the multi-session pointers of a Polymorphic TOC may be altered. As described hereinabove with reference to Fig. 4, a multi-session disc has a set of multi-session pointers 62 that are interleaved between the standard track pointers 60 and allow navigation between sessions in a linked list.

In one embodiment, the multi-session pointers 136 (marked "a") (equivalent to multi-session pointers 62 in Fig. 4) may be left unaltered, regardless of processing of triplets 138, 140. The C/A values of two of the triplets 138, 140 have been altered to "41" instead of "01" in multi-session pointers 60 of Fig. 4. Similarly, multi-session pointers 142 (equivalent to multi-session pointers 64 in Fig. 4) is unaltered.

The example of Fig. 18 further illustrates two alternative ways of altering the multi-session pointers. In triplet 144 (marked "b"), the multi-session pointers may be invalidated in the same ways as the surrounding track pointers of triplets 146, 148. In triplet 150, the multi-session pointers be invalidated in a way that is different from the surrounding track pointers so that part of the C/A triplet is altered to give a misleading (and invalid) reading of "48". Modifications may occur in any of the three items in a triplet.

While this example demonstrates polymorphic multi-session triplets, it will be appreciated by persons knowledgeable in the art that polymorphic TOCs may also be similarly amended.

Reference is now made to Fig. 19 which is an exemplary illustration of an embodiment of the present invention in which polymorphic TOCs include both a polymorphic TOC and multi-session pointers that are all invalidated. In the example of Fig. 19, all alterations are italicized and the multi-session pointers are bolded. The second audio track 152 has a misleading Ctrl in the second TOC

shown (Ctrl = 4, indicating DATA, rather than AUDIO) and all the B0 multi-session pointers 154 have an invalid ADR (ADR = 8).

This type of modification can be made to polymorphic TOCs that have polymorphic triplets in which the multi-session pointers all point to an incorrect location in the Program Area. Reference is now made to Fig. 20 which is an exemplary illustration of an embodiment of the present invention in which a composite disc, (described hereinabove with reference to Fig. 16), may also include multi-session pointers invalidated in a polymorphic manner. For example, in Fig. 20, the bold lines 160, 162 indicate the invalidated multi-session pointers.

It will be appreciated that in a composite disc, different multi-session effects may be applied to each zone. Furthermore, certain zones may eliminate multi-session pointers altogether, effectively "hiding" the second session. In a disc with more than two sessions, a middle session may be hidden in certain device classes by restricting or modifying the multi-session pointers or eliminating them on a zone-by-zone basis.

Reference is now made to Fig. 21, which is a flow-chart illustration of a method of generating a Polymorphic TOC disc.

The CD-R writer determines that a blank CD-R is in place in the drive and is initialized in Raw DAO mode (step 202). The cue sheet (204) is read (step 206) and a memory image of the lead-in to be produced is created (step 208). The cue sheet describes the layout of the disc in terms of tracks. At a minimum, the cue sheet may provide the absolute time offset in frames for each track and the total number of tracks.

The lead-in is formed in the channel Q of successive frames and submitted (step 210) in blocks of frames to the writer. For each frame, an algorithm, which generates the form of polymorphism applicable to that frame, may be applied. The correct Q channel is placed into the raw stream that is submitted to the writer (step 212).

After the lead-in is written, the Program Area is written (step 216) using the image file (214). The image file may be a 44.1K sample per second stereo (16 bits per sample) PCM file containing the main channel of the disc as a waveform, or a raw 2352-byte per sector ISO file for a data disc. The subchannel is calculated normally for each frame according to the algorithms in IEC 908. The lead-out is then written (step 218).

In a multi-session disc, steps 206- 218 repeated for each session.

It may be useful to create a valid audio TOC, for example, for use in a first session. One method of creating a valid audio TOC may read the TOC sequentially, only the basic parameters from the TOC are determined. The basic parameters must be valid regardless of polymorphism, and thus a true TOC may be recreated by reading the Program Area entries pointed to by any valid triplets.

Figure 22, to which reference is now made, is a flow-chart illustration of a method for creating a true lead-in. The TOC is read (step 252) and for each triplet in the instance of the TOC, the triplet is analyzed (step 254). If the triplet is not uniform (query box 256) , it is discarded (step 258).

If the triplet is uniform, the ATime pointed to by the triplet is sought and the Q channel at the Atime in the Program Area is read (step 260). An analysis (step 262) of the frames (both backwards and forwards of the Atime) is then made. For example, since one second of time is equivalent to 75 frames, by analyzing one second either side of the Atime, it should be possible to locate a frame with the same track number as the triplet within one second of the Atime. However, an analysis may be made for a longer period.

Thus, for example if the track number (TNO) (of the next backward frame) is not one less than the track number (TNO) of the following frame (query box 264), the triplet is discarded (step 258). If the ADR/Ctrl field of the triplet has the data bit set but the frame does not have the corresponding data bit set, the bit is reset to audio. If the track number (TNO) is correct, the triplet is saved into a memory reconstruction of the TOC (step 266).

If an instance is incomplete (for example, if the A0–A2 items indicate more tracks or a longer disc than the reconstructed TOC), steps 254-266 are repeated for the next instance of the TOC.

Once a complete and valid TOC has been reconstructed, the disc may be read according to the reconstructed valid TOC.

In an alternative embodiment, the entire Program Area may be read in 2448-byte raw mode, thereby preserving the main channel and subchannel. Following the entire read, the channel Q may be analyzed using the algorithm illustrated in Fig. 23 to which reference is now made.

The entire disc is read in raw mode (step 282) and the channel Q of the frame is read (step 284). The track number (TNO) of the frame is compared with

track number (TNO) of the previous frame (query box 286). If the track number (TNO) is the same as the previous track number (TNO), the next frame is then read (steps 288) and steps 284-286 are repeated. If the track number (TNO) is greater than the previous frame, a TOC entry with the new track number and the ATime of the current frame is created l(step 290).

Steps 284-290 are then repeated until the end of the disc (step 292). Each track may then be interpreted from its image in the correct mode.

This document describes examples applying polymorphic lead-ins to the audio portion of an audio or multi-session audio-data disc; however, all such examples are non-limiting.

While the invention has been described with respect to a limited number of embodiments, it will be appreciated that many variations, modifications and other applications of the invention may be made.

CLAIMS

1. An optical disc having at least one session, said at least one session comprising a lead-in having a plurality of subcoding blocks, each of said plurality of subcoding blocks comprising an item in channel Q, said item comprising at least a Point (PT), Adr/Ctrl, Pmin, Psec and Pframe

wherein the Point of at least one of said plurality of subcoding blocks is identical to the Point in at least one other of said plurality of subcoding blocks; and

wherein the value of at least one of a group including Adr/Ctrl, Pmin, Psec and Pframe in said at least one of said plurality of subcoding blocks differs from the value of at least one of the corresponding group of Adr/Ctrl, Pmin, Psec and Pframe in said at least one other of said plurality of subcoding blocks.

2. The optical disc according to claim 1, wherein said plurality of subcoding blocks comprise a repetition of items, wherein at least one of the group including Adr/Ctrl, Pmin, Psec and Pframe of at least one of said repetition of items is altered.

3. The optical disc according to claim 2, wherein at least one of the values in the control data of said one of said repetition of items is replaced by a misleading or invalid value.

4. The optical disc according to claim 3, wherein said misleading or invalid value comprises an indication that an audio portion of the disc contains data or vice versa.

5. The optical disc according to claim 3, wherein said misleading or invalid triplet comprises an indication that that the starting time of the track is invalid or misleading

6. The optical disc according to claim 2, wherein at least one of the values of the Cyclic Redundancy Check (CRC) of said one of said repetition of items is replaced by a misleading or invalid value .

7. The optical disc according to claim 1, wherein said plurality of subcoding blocks comprise a continuous repetition of table of contents (TOCs), wherein at

least one item in at least one of the group including Adr/Ctrl, Pmin, Psec and Pframe of one of said repetition of table of contents (TOCs) has a different value from the corresponding item in at least one other of said repetition of table of contents (TOCs).

8. The optical disc according to claim 7, wherein said one of said repetition of table of contents (TOCs) comprises a misleading or invalid triplet. .

9. The optical disc according to claim 8, wherein said misleading or invalid triplet comprises an indication that an audio portion of the disc contains data or vice versa.

10. The optical disc according to claim 8, wherein said misleading or invalid triplet comprises an indication that that the starting time of the track is invalid or misleading.

11. The optical disc according to claim 8, wherein said misleading or invalid triplet comprises a misleading or invalid point.

12. The optical disc according to claim 8, wherein said misleading or invalid triplet comprises setting the Adr/Ctrl field to an invalid value.

13. The optical disc according to claim 7, wherein said one of said repetition of table of contents (TOCs) comprises an interleaved pattern of alternating valid and invalid triplets.

14. The optical disc according to claim 13, wherein said alternating valid and invalid triplets are represented by audio and data item respectively, or vice versa.

15. The optical disc according to claim 13, wherein said pattern is randomized.

16. The optical disc according to claim 15, wherein each track is represented by at least one audio and one data item.

17. The optical disc according to claim 15, wherein one of the points of said one of said repetition of table of contents (TOCs) remain uniform.

18. The optical disc according to claim 7, wherein said one of said repetition of table of contents (TOCs) comprises one of a group including at least one misleading or invalid triplet.

19. The optical disc according to claim 1, wherein said plurality of subcoding blocks comprise a combination of a repetition of items, and continuous repetition of table of contents (TOCs),

wherein at least one of the group including Adr/Ctrl, Pmin, Psec and Pframe of at least one of said repetition of items is altered; and at least one item in at least one of the group including Adr/Ctrl, Pmin, Psec and Pframe of one of said repetition of table of contents (TOCs) has a different value from the corresponding item in at least one other of said repetition of table of contents (TOCs).

20. The optical disc according to claim 1, wherein said plurality of subcoding blocks comprise a plurality of zones, wherein an alteration algorithm is applied to each of said plurality of zones.

21. The optical disc according to claim 20, wherein said plurality of zones comprise any combination of a group including a valid table of contents (TOCs), an invalid table of contents (TOCs), an interleaved pattern of alternating valid and invalid entries and one of a group including at least one data track or at least one invalid triplet,

wherein said invalid table of contents (TOCs) comprises one repetition of the table of contents (TOCs), which is different from at least one other of repetition of the table of contents (TOCs).

22. The optical disc according to claim 7, wherein the A0, A1, and A2 points have invalid or misleading values.

23. The optical disc according to claim 1 further comprising a multi-session disc having a plurality of multi-session pointers, wherein at least one of said plurality of multi-session pointers is invalid or misleading.

24. The optical disc according to claim 20, further comprising a multi-session disc having a plurality of multi-session pointers, wherein at least one of said plurality of multi-session pointers is invalid or misleading.

25. The optical disc according to claim 1, wherein said optical disc comprises one of a group including a compact disc (CD) a recordable compact disc (CD-R) and a CD-Rewritable compact disc (CD-RW).

26. A method for protecting an optical disc from unauthorized copying, said method comprising the steps of:

generating a lead-in, said lead-in having a plurality of subcoding blocks, each of said plurality of subcoding blocks , comprising an item, said item comprising at least a Point (PT), Adr/Ctrl, Pmin, Psec and Pframe, and

altering the value of at least one of a group including Adr/Ctrl, Pmin, Psec and Pframe in said at least one of said plurality of subcoding blocks to a value different from at least one of the corresponding group of Adr/Ctrl, Pmin, Psec and Pframe in said at least one other of said plurality of subcoding blocks.

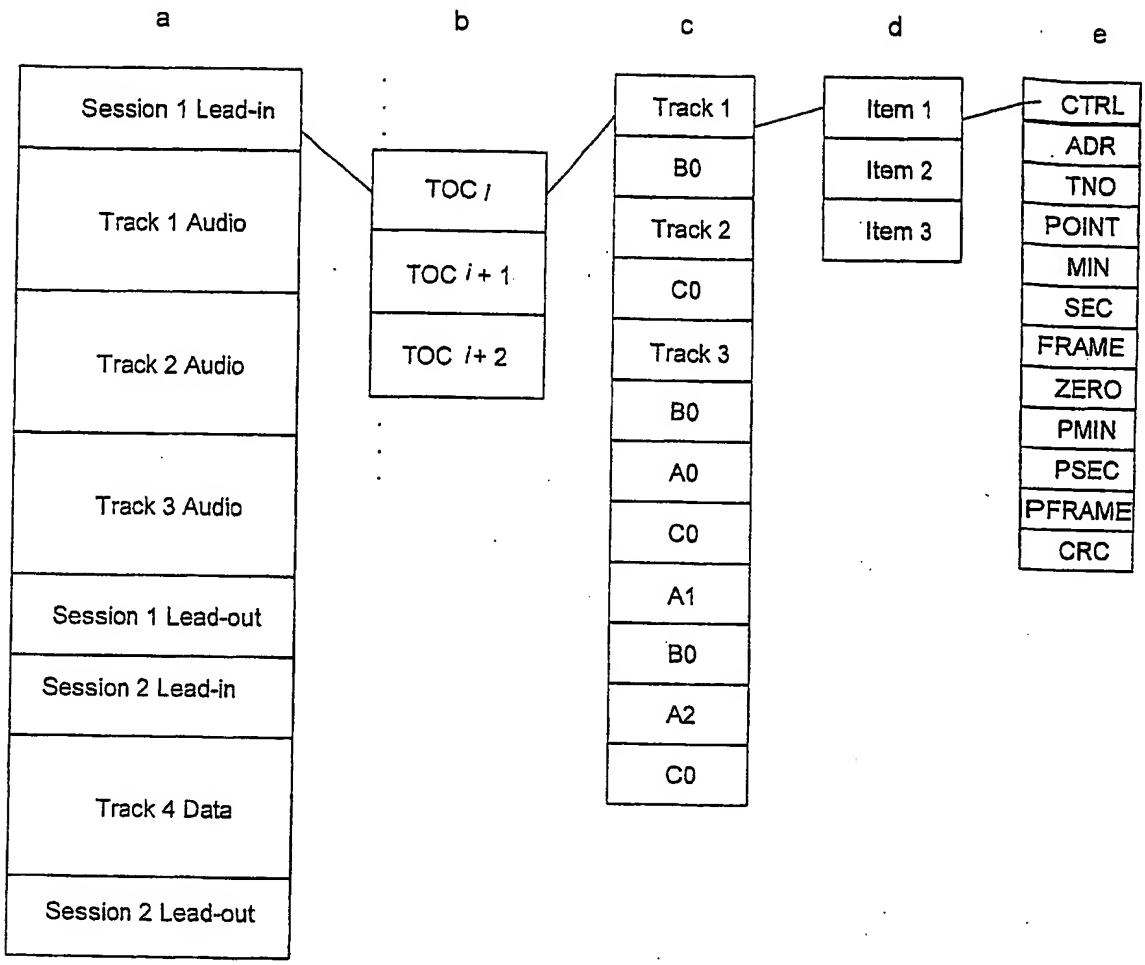
27. A method for generating a valid lead-in containing continuous repetition of table of contents (TOCs), said method comprising the step of:

reading the Program Area subcoding blocks pointed to by said continuous repetition of table of contents (TOCs); and

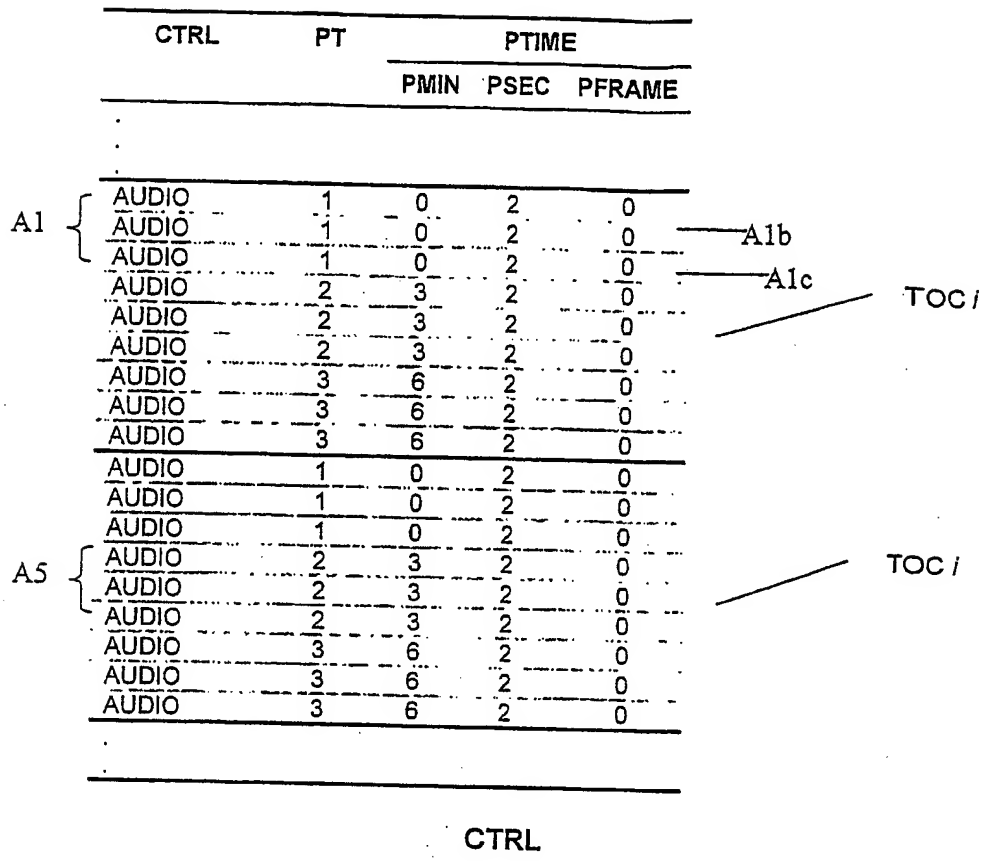
discarding invalid or misleading triplets, so determined by said reading of Program Area.

28. A method for generating a valid lead-in containing continuous repetition of table of contents (TOCs), said method comprising the steps of:

a. reading the entire Program Area;
b. reading the channel Q of a frame being analyzed;
c. comparing the track number (TNO) of the analyzed frame with the track number (TNO) of the previous frame;
d. if the track number (TNO) of the analyzed frame is greater than the track number (TNO) of the previous frame, creating a TOC entry with the new track number and the ATime of the analyzed frame.



FIGS. 1a-1e (Prior Art)



	CTRL	PT	PTIME		
			PMIN	PSEC	PFRAME
	.				
	.				
	.				
A1	AUDIO	1	0	2	0
	AUDIO	1	0	2	0
	AUDIO	1	0	2	0
	AUDIO	2	3	2	0
	AUDIO	2	3	2	0
	AUDIO	2	3	2	0
	AUDIO	3	6	2	0
	AUDIO	3	6	2	0
	AUDIO	3	6	2	0
	AUDIO	1	0	2	0
	AUDIO	1	0	2	0
	AUDIO	1	0	2	0
A5	AUDIO	2	3	2	0
	AUDIO	2	3	2	0
	AUDIO	2	3	2	0
	AUDIO	3	6	2	0
	AUDIO	3	6	2	0
	AUDIO	3	6	2	0
	.				
	.				
	CTRL				

FIG 2 (Prior Art)

C/A	TNO	PT	MI	SE	FR	ZE	PM	PS	PF
01	00	01	97	31	39	00	00	02	00
01	00	01	97	31	40	00	00	02	00
01	00	01	97	31	41	00	00	02	00
01	00	02	97	31	45	00	01	02	00
01	00	02	97	31	46	00	01	02	00
01	00	02	97	31	47	00	01	02	00
01	00	03	97	31	51	00	02	02	00
01	00	03	97	31	52	00	02	02	00
01	00	03	97	31	53	00	02	02	00
01	00	A0	97	32	18	00	01	00	00
01	00	A0	97	32	19	00	01	00	00
01	00	A0	97	32	20	00	01	00	00
01	00	A1	97	32	24	00	09	00	00
01	00	A1	97	32	25	00	09	00	00
01	00	A1	97	32	26	00	09	00	00
01	00	A2	97	32	30	00	09	00	00
01	00	A2	97	32	31	00	09	00	00
01	00	A2	97	32	32	00	09	00	00

Legend:

C/A	CTRL/ADR
TNO	TNO
PT	POINT
MI	MIN
SE	SEC
FR	FRAME
ZE	ZERO
PM	PMIN
PS	PSEC
PF	PFRAME

FIG 3 (Prior Art)

C/A	TNO	PT	MI	SE	FR	ZE	PM	PS	PF	
01	00	01	97	31	39	00	00	02	00	
01	00	01	97	31	40	00	00	02	00	
01	00	01	97	31	41	00	00	02	00	60
05	00	B0	11	30	00	02	11	34	27	
05	00	B0	11	30	00	02	11	34	27	
05	00	B0	11	30	00	02	11	34	27	62
01	00	02	97	31	45	00	01	02	00	
01	00	02	97	31	46	00	01	02	00	
01	00	02	97	31	47	00	01	02	00	60
05	00	C0	80	00	00	00	97	18	06	
05	00	C0	80	00	00	00	97	18	06	
05	00	C0	80	00	00	00	97	18	06	64
01	00	03	97	31	51	00	02	02	00	
01	00	03	97	31	52	00	02	02	00	
01	00	03	97	31	53	00	02	02	00	
05	00	B0	11	30	00	02	11	34	27	
05	00	B0	11	30	00	02	11	34	27	
05	00	B0	11	30	00	02	11	34	27	62
01	00	A0	97	32	18	00	01	00	00	
01	00	A0	97	32	19	00	01	00	00	
01	00	A0	97	32	20	00	01	00	00	
05	00	C0	80	00	00	00	97	18	06	
05	00	C0	80	00	00	00	97	18	06	
05	00	C0	80	00	00	00	97	18	06	64
01	00	A1	97	32	24	00	09	00	00	
01	00	A1	97	32	25	00	09	00	00	
01	00	A1	97	32	26	00	09	00	00	
05	00	B0	11	30	00	02	11	34	27	
05	00	B0	11	30	00	02	11	34	27	
05	00	B0	11	30	00	02	11	34	27	62
01	00	A2	97	32	30	00	09	00	00	
01	00	A2	97	32	31	00	09	00	00	
01	00	A2	97	32	32	00	09	00	00	
05	00	C0	80	00	00	00	97	18	06	
05	00	C0	80	00	00	00	97	18	06	
05	00	C0	80	00	00	00	97	18	06	64

FIG 4 (Prior Art)

CTRL	ADR	POINT	MIN	SEC	FRAME	ZERO	PMIN	PSEC	PFRAME	CRC
*	*	*					*	*	*	
Item 1										
CTRL	ADR	POINT	MIN	SEC	FRAME	ZERO	PMIN	PSEC	PFRAME	CRC
*	*	*					*	*	*	
Item 2										

FIG. 5 (Prior Art)

CTRL	PT	PTIME		
		PMIN	PSEC	PFRAME
AUDIO	1	0	2	0
DATA (a)	1	0	2	0
AUDIO	1	0	2	0

Misleading item

FIG 6

CRTL	PT	PTIME			CRC
		PMIN	PSEC	PFRAME	
AUDIO	1	0	2	0	45
AUDIO	1	0	2	0	45
AUDIO	1	0	2	0	5 (a)

Invalid item

FIG 7

CTRL	PT	PTIME		
		PMIN	PSEC	PFRAME
AUDIO	1	0	2	0
AUDIO	1	0	2	0
AUDIO	1	0	2	0
AUDIO	**2**	**3**	**2**	**0**
AUDIO	**2**	**3**	**2**	**0 (a)**
AUDIO	**2**	**3**	**2**	**0**
AUDIO	3	6	2	0
AUDIO	3	6	2	0
AUDIO	3	6	2	0
AUDIO	1	0	2	0
AUDIO	1	0	2	0
AUDIO	1	0	2	0
DATA	**2**	**3**	**2**	**0**
DATA	**2**	**3**	**2**	**0 (b)**
DATA	**2**	**3**	**2**	**0**
AUDIO	3	6	2	0
AUDIO	3	6	2	0
AUDIO	3	6	2	0

TOC *i*

Misleading item

TOC *i+1*

FIG 8

CTRL	PT	PTIME		
		PMIN	PSEC	PFRAME
AUDIO	1	0	2	0
AUDIO	1	0	2	0
AUDIO	1	0	2	0
AUDIO	2	3	2	0
AUDIO	2	3	2	0
AUDIO	2	3	2	0
AUDIO	3	6	2	0
AUDIO	3	6	2	0
AUDIO	3	6	2	0
AUDIO	1	0	2	0
AUDIO	1	0	2	0
AUDIO	1	0	2	0
AUDIO	**3 (a)**	**3**	**2**	**0**
AUDIO	**3 (a)**	**3**	**2**	**0**
AUDIO	**3 (a)**	**3**	**2**	**0**
AUDIO	3	6	2	0
AUDIO	3	6	2	0
AUDIO	3	6	2	0

TOC *i*

Misleading item

TOC *i* + 1

FIG 9

ADR	PT	PTIME		
		PMIN	PSEC	PFRAME
1	1	0	2	0
1	1	0	2	0
1	1	0	2	0
1	2	3	2	0
1	2	3	2	0
1	2	3	2	0
1	3	6	2	0
1	3	6	2	0
1	3	6	2	0
1	1	0	2	0
1	1	0	2	0
1	1	0	2	0
8	2	3	2	0
8 (a)	2	3	2	0
8	2	3	2	0
1	3	6	2	0
1	3	6	2	0
1	3	6	2	0

TOC *i*

Misleading item

TOC *i*

FIG 10

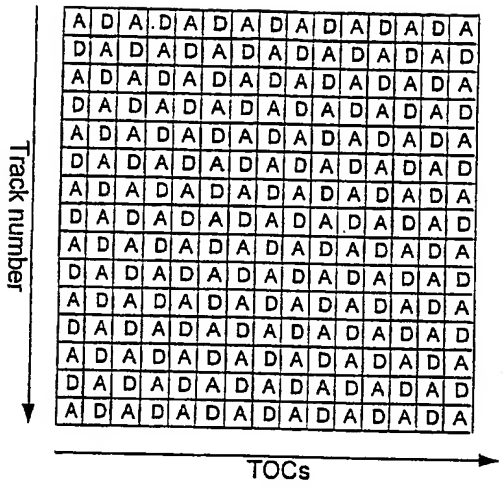


FIG 11

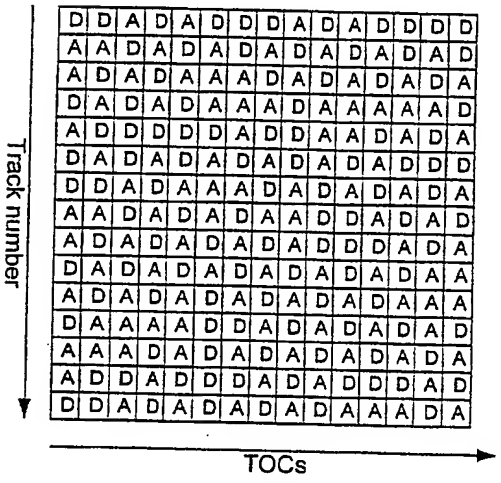


FIG 12

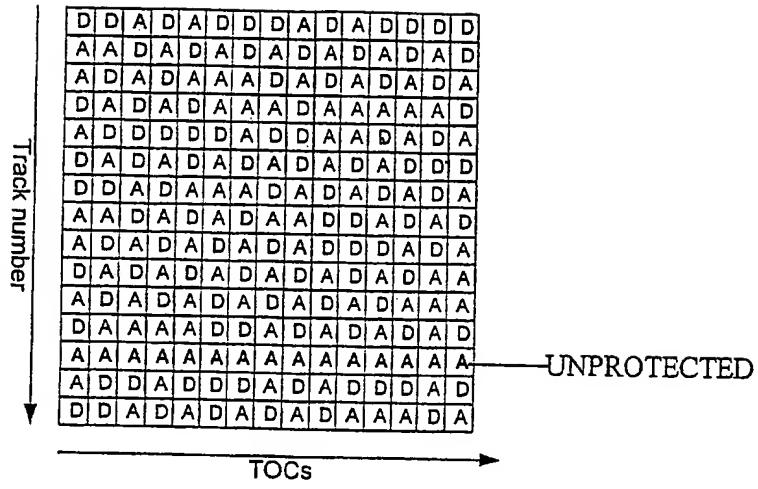

Track number
TOCs
UNPROTECTED

FIG 13

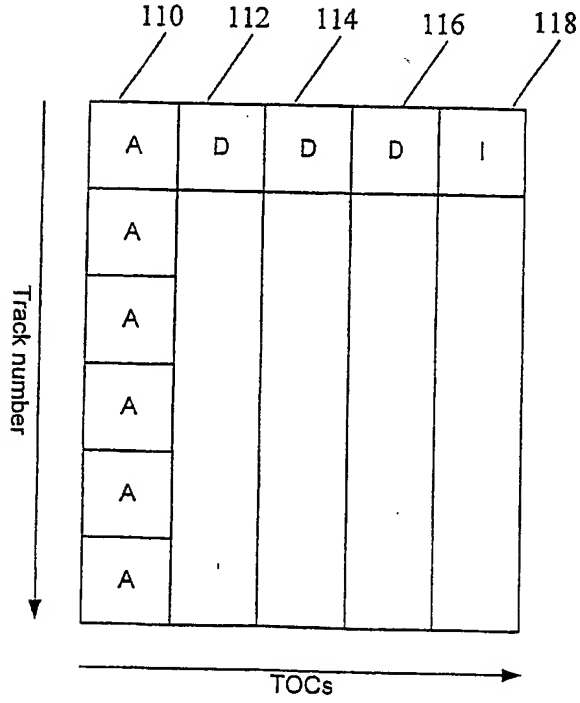

110
112
114
116
118
A
D
D
D
I
A
A
A
A
A
Track number
TOCs

FIG 14.

CTRL	PT	PTIME		
		PMIN	PSEC	PFRAME
AUDIO	1	0	2	0
DATA	1	0	2	0 (a)
AUDIO	1	0	2	0
AUDIO	2	3	2	0
AUDIO	2	3	2	0
AUDIO	2	3	2	0
AUDIO	3	6	2	0
AUDIO	3	6	2	0
AUDIO	3	6	2	0
AUDIO	1	0	2	0
AUDIO	1	0	2	0
AUDIO	1	0	2	0
DATA	2	3	2	0
DATA	2	3	2	0 (b)
DATA	2	3	2	0
AUDIO	3	6	2	0
AUDIO	3	6	2	0
AUDIO	3	6	2	0

Misleading item

TOC *i*

Misleading items

TOC *i* + 1

FIG. 15

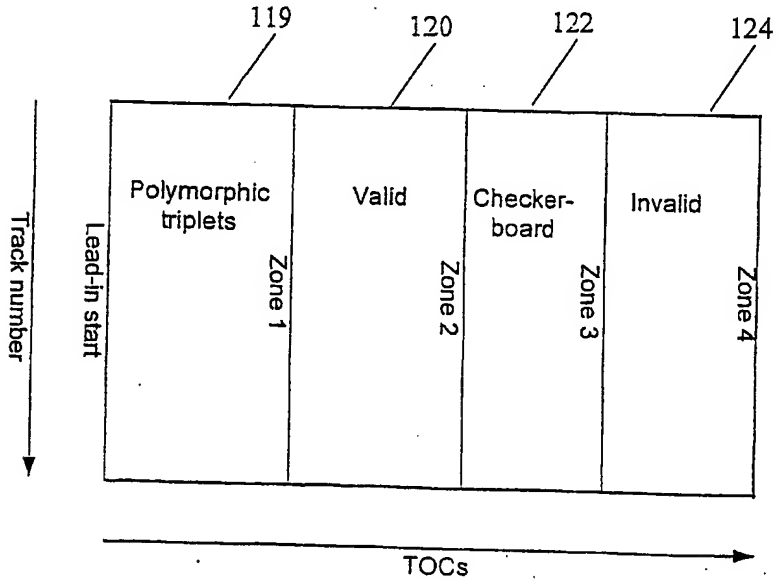


FIG. 16

	C/A	TNO	PT	MI	SE	FR	ZE	AM	AS	AF	
126	41	00	01	97	31	39	00	00	02	00	
	01	00	01	97	31	40	00	00	02	00	
	41	00	01	97	31	41	00	00	02	00	
	01	00	02	97	31	45	00	01	02	00	
	01	00	02	97	31	46	00	01	02	00	
	01	00	02	97	31	47	00	01	02	00	
	01	00	03	97	31	51	00	02	02	00	
	01	00	03	97	31	52	00	02	02	00	
	01	00	03	97	31	53	00	02	02	00	
128	01	00	A0	97	32	18	00	01	00	00	
	01	00	A0	97	32	19	00	01	00	00	(a)
	01	00	A0	97	32	20	00	01	00	00	
130	41	00	A1	97	32	24	00	09	00	00	
	01	00	A1	97	32	25	00	09	00	00	(b)
	41	00	A1	97	32	26	00	09	00	00	
132	01	00	A2	97	32	30	00	09	00	00	
	48	00	A2	97	32	31	00	09	00	00	(c)
	48	00	A2	97	32	32	00	09	00	00	

FIG. 17

C/A	TNO	PT	MI	SE	FR	ZE	AM	AS	AF	
41	00	01	97	31	39	00	00	02	00	
01	00	01	97	31	40	00	00	02	00	138
41	00	01	97	31	41	00	00	02	00	
05	00	B0	11	30	00	02	11	34	27	
05	00	B0	11	30	00	02	11	34	27	(a) 136
05	00	B0	11	30	00	02	11	34	27	
41	00	02	97	31	45	00	01	02	00	
01	00	02	97	31	46	00	01	02	00	
41	00	02	97	31	47	00	01	02	00	
05	00	C0	80	00	00	00	97	18	06	
05	00	C0	80	00	00	00	97	18	06	140
05	00	C0	80	00	00	00	97	18	06	
01	00	03	97	31	51	00	05	02	00	
01	00	03	97	31	52	00	02	02	00	142
01	00	03	97	31	53	00	05	02	00	
05	00	B0	11	30	00	02	16	34	27	
05	00	B0	11	30	00	02	11	34	27	(b) 146
05	00	B0	11	30	00	02	16	34	27	
01	00	04	97	31	57	00	04	02	00	
01	00	04	97	32	58	00	03	00	00	148
01	00	04	97	31	59	00	04	02	00	
05	00	C0	80	00	00	00	97	18	06	
05	00	C0	80	00	00	00	97	18	06	
05	00	C0	80	00	00	00	97	18	06	
01	00	05	97	32	63	00	04	02	00	
01	00	05	97	32	64	00	04	02	00	
01	00	05	97	32	65	00	04	02	00	
05	00	B0	11	30	00	02	11	34	27	
48	00	CC	11	30	00	02	11	34	27	(c) 150
48	00	CC	11	30	00	02	11	34	27	
01	00	06	97	31	69	00	05	02	00	
01	00	06	97	31	70	00	09	02	00	
01	00	06	97	31	71	00	09	02	00	

FIG. 18

C/A	TNO	PT	MI	SE	FR	ZE	AM	AS	AF	
01	00	01	97	31	39	00	00	02	00	
01	00	01	97	31	40	00	00	02	00	
01	00	01	97	31	41	00	00	02	00	
08	*00*	*B0*	*11*	*30*	*00*	*02*	*11*	*34*	*27*	
08	*00*	*B0*	*11*	*30*	*00*	*02*	*11*	*34*	*27*	154
08	*00*	*B0*	*11*	*30*	*00*	*02*	*11*	*34*	*27*	
01	00	02	97	31	45	00	01	02	00	
01	00	02	97	31	46	00	01	02	00	
01	00	02	97	31	47	00	01	02	00	
05	**00**	**C0**	**80**	**00**	**00**	**00**	**97**	**18**	**06**	
05	**00**	**C0**	**80**	**00**	**00**	**00**	**97**	**18**	**06**	
05	**00**	**C0**	**80**	**00**	**00**	**00**	**97**	**18**	**06**	
01	00	05	97	32	63	00	04	02	00	
01	00	05	97	32	64	00	04	02	00	
01	00	05	97	32	65	00	04	02	00	
08	*00*	*B0*	*11*	*30*	*00*	*02*	*11*	*34*	*27*	
08	*00*	*B0*	*11*	*30*	*00*	*02*	*11*	*34*	*27*	
08	*00*	*B0*	*11*	*30*	*00*	*02*	*11*	*34*	*27*	
01	00	06	97	31	69	00	05	02	00	
01	00	06	97	31	70	00	09	02	00	
01	00	06	97	31	71	00	09	02	00	
05	**00**	**C0**	**80**	**00**	**00**	**00**	**97**	**18**	**06**	
05	**00**	**C0**	**80**	**00**	**00**	**00**	**97**	**18**	**06**	
05	**00**	**C0**	**80**	**00**	**00**	**00**	**97**	**18**	**06**	
01	00	01	97	31	39	00	00	02	00	
01	00	01	97	31	40	00	00	02	00	
01	00	01	97	31	41	00	00	02	00	
08	*00*	*B0*	*11*	*30*	*00*	*02*	*11*	*34*	*27*	
08	*00*	*B0*	*11*	*30*	*00*	*02*	*11*	*34*	*27*	
08	*00*	*B0*	*11*	*30*	*00*	*02*	*11*	*34*	*27*	
41	*00*	*02*	*97*	*31*	*45*	*00*	*01*	*02*	*00*	
41	*00*	*02*	*97*	*31*	*46*	*00*	*01*	*02*	*00*	152
41	*00*	*02*	*97*	*31*	*47*	*00*	*01*	*02*	*00*	

FIG. 19

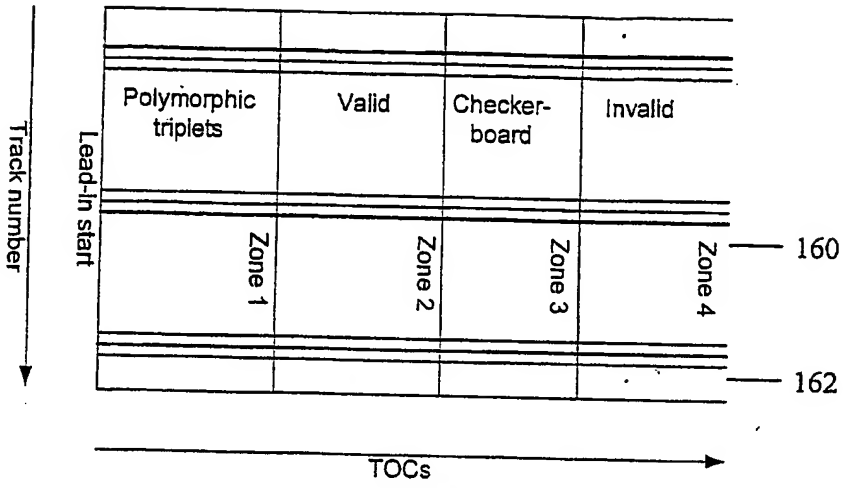

Track number
Lead-in start
Polymorphic triplets
Valid
Checker-board
Invalid
Zone 1
Zone 2
Zone 3
Zone 4
160
162
TOCs

FIG. 20

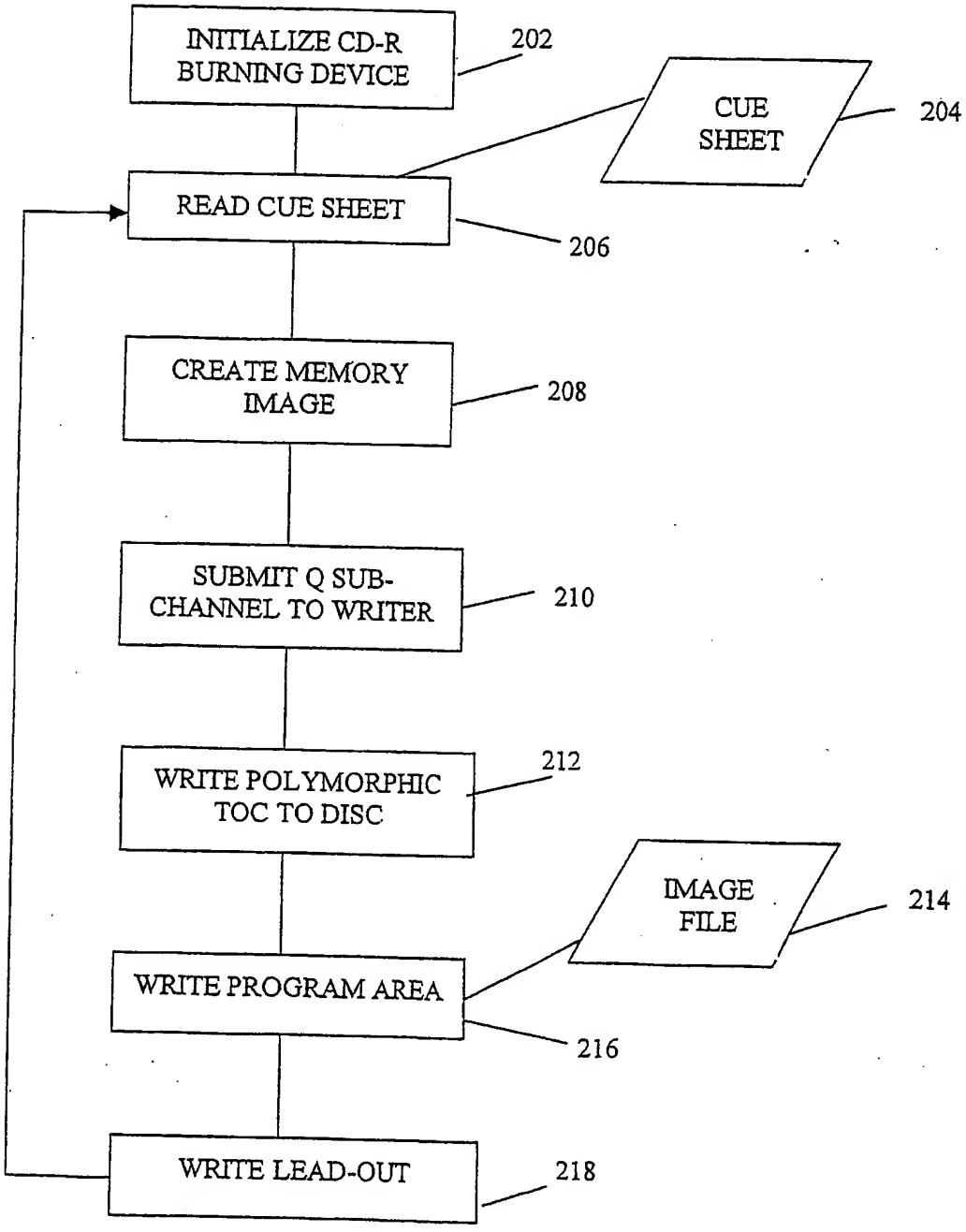

INITIALIZE CD-R BURNING DEVICE
202
CUE SHEET
204
READ CUE SHEET
206
CREATE MEMORY IMAGE
208
SUBMIT Q SUB-CHANNEL TO WRITER
210
WRITE POLYMORPHIC TOC TO DISC
212
IMAGE FILE
214
WRITE PROGRAM AREA
216
WRITE LEAD-OUT
218

FIG. 21

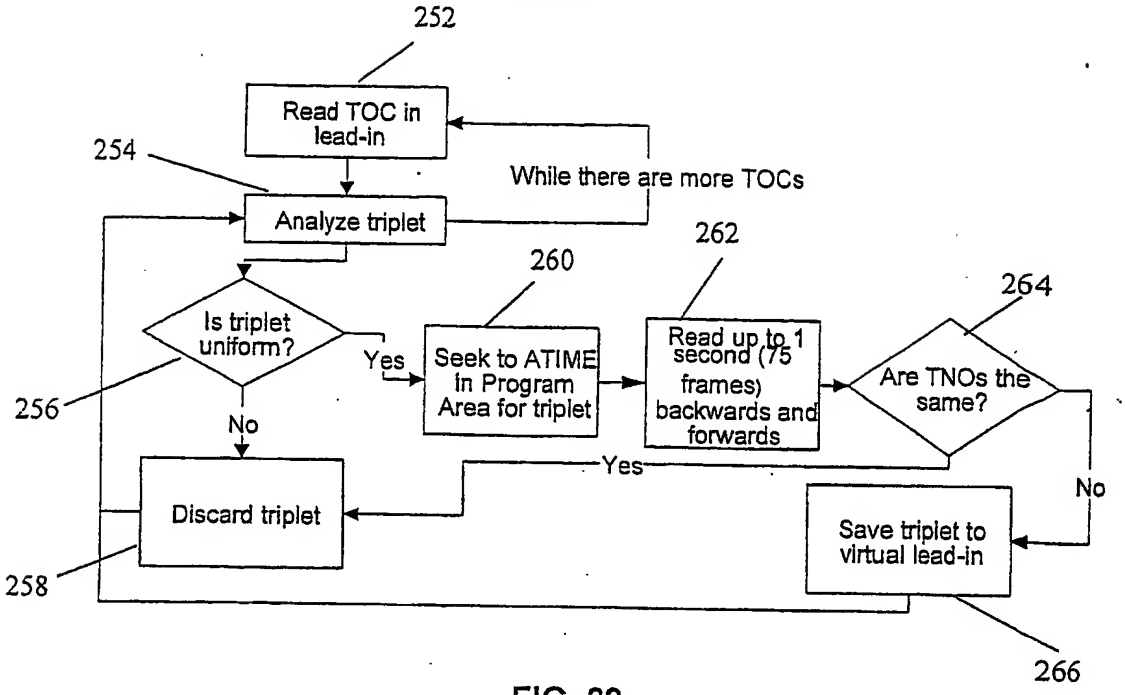

252
Read TOC in lead-in
254
While there are more TOCs
Analyze triplet
262
260
264
Is triplet uniform?
Yes
Seek to ATIME in Program Area for triplet
Read up to 1 second (75 frames) backwards and forwards
Are TNOs the same?
256
No
Yes
No
Discard triplet
Save triplet to virtual lead-in
258
266

FIG. 22

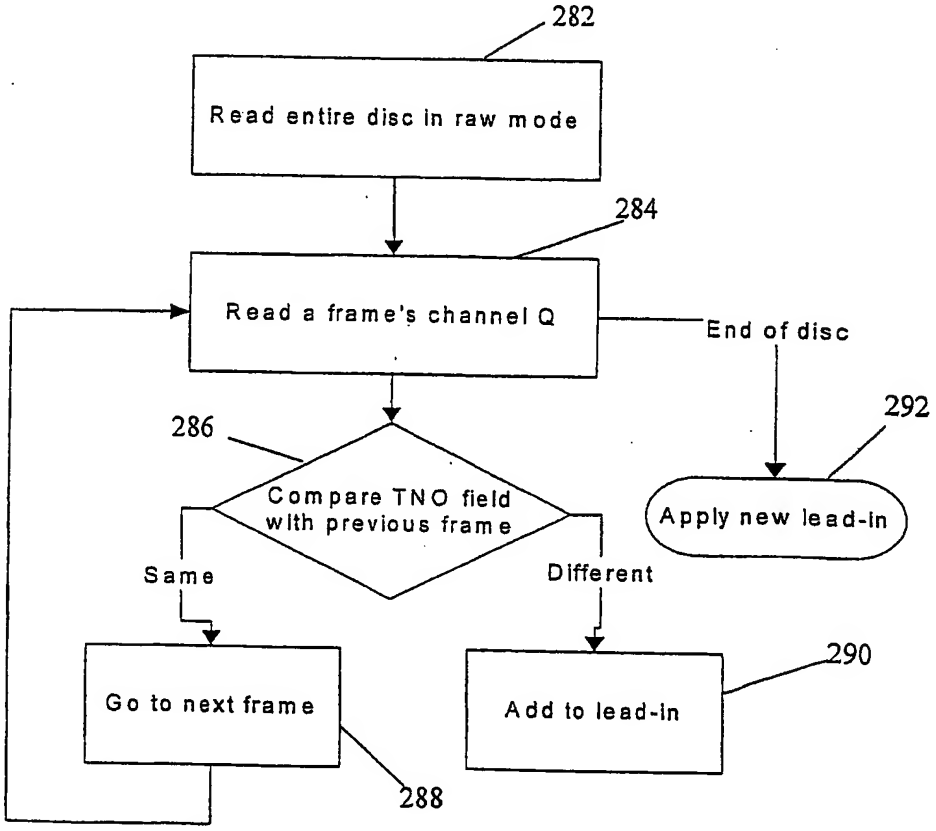

282
Read entire disc in raw mode
284
Read a frame's channel Q
End of disc
292
286
Compare TNO field with previous frame
Apply new lead-in
Same
Different
290
Go to next frame
Add to lead-in
288

FIG. 23